EXPERIMENTS OF DUST THRESHOLD AND FLUX UNDER MARTIAN CONDITIONS. G. R. Wilson[1], R. Greeley[2], and B. R. White[3] [1]Arizona State University, Department of Geology at NASA Ames Research Center, M.S. 242-6, Moffett Field, CA 94035 (gwilson@humbabe.arc.nasa.gov), [2]Arizona State University, Department of Geology, Box 871404, Tempe, AZ, 85287 (greeley@asu.edu), and [3]University of California, Davis, Department of Mechanical, Aeronautical and Materials Engineering, Davis, CA 95616 (brwhite@usdavis.edu).

Introduction: The threshold, flux, and behavior of dust (particles 1-2 microns in diameter) was analyzed in a simulated Martian environment. This particle size is representative of Martian atmospheric dust based on results from the Mariner 9 and Viking spacecraft. The threshold and flux curves for particles greater than 10 µm in diameter have been previously studied in the Mars Surface Wind Tunnel (MARSWIT); however, particles less than 10 µm have not been rigorously analyzed primarily because these small particles are difficult to work with. Preliminary MARSWIT results of dust threshold and flux as a function of wind shear, surface roughness, and surface polarity are presented, as well as, experimental procedures. These results suggest that surface roughness and inter-particle forces have a far more dominant effect on 1-2 µm particles than they do on 10-1000 micron particles. Applications of these results indicate that rocky surfaces have a greater potential for dust raising than smooth plains, consistent with Viking observations.

Objectives: The objectives of this study are to investigate behavior of dust (1-2 µm) under Martian atmospheric conditions. This includes identification of the threshold friction velocity and flux of particles as a function of surface roughness and surface charge. The primary focus of this poster will present the dust threshold and flux from a smooth surface as a function of surface polarity.

Experiment: The test section of the Mars Surface Wind Tunnel at NASA Ames Research Center was equipped with three aluminum plates measuring 30 cm wide and 120 cm long. These plates are placed parallel to each other and oriented with the direction of the wind. Each plate has eight removable disks, 10 cm in diameter, which are spaced in alternating rows 15 cm apart. All 24 disks are raised and lowered precisely into place by a cam mechanism, which allowed them to be removed from the test bed without disturbing the surrounding area (Figure 1). Each plate is electrically isolated where one can be positively charged, the second negatively charged, and the third grounded.

To produce a natural surface condition, Carbondale Red Clay (CRC), which has been determined to be an appropriate surrogate Martian dust [1], was allowed to aerodynamically settle over the test section. This was accomplished by placing a mixture of sand and CRC into a 4 liter container covered with a fine mesh screen. Compressed air was then injected into the container which dispersed the CRC material with the aid of the swirling sand grains. The purpose of the screen was to trap the sand grains but still allow the fine dust to escape. This procedure takes place in a removable cover that is placed over the test bed inside the wind tunnel. After letting all the dust settle over surface during a period of 12 hours, the resulting dust bed measured approximately 0.2 cm thick and covered the entire test bed.

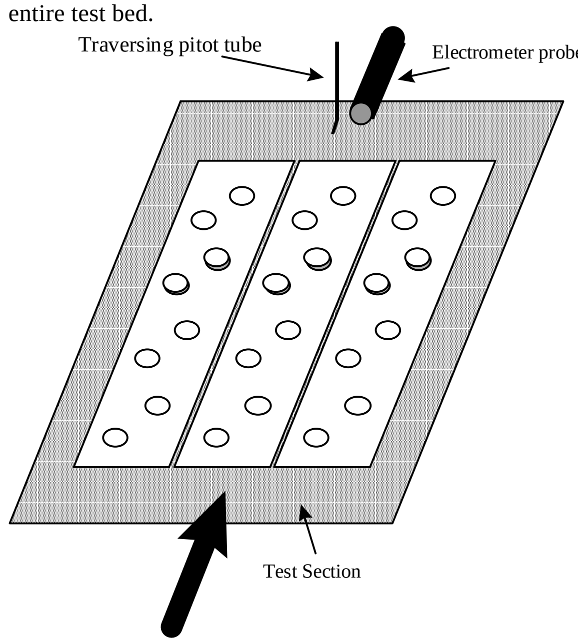

Figure 1. Test section configuration.

Through the process of charge separation and contact charging, the large sand grains can acquire a mean positive charge while the small dust particles are charged negatively [2,3].

Dust threshold is measured using an electrometer probe and visualized using a high-resolution television camera system. According to previous experiments, the electrometer probe will produce a signal once the threshold is obtained. With the high-resolution images of the test bed, the threshold can be indicated through the visually detected changes in albedo attributed to particle removal. Although the latter experimental procedure is a less definitive indicator than the signal from the electrometer probe, it can still provide a supporting view of the dust threshold.

In order to attain the desired atmospheric boundary layer surface conditions, the test bed must be placed inside the turbulent region. With Earth atmospheric pressures, a naturally turbulent boundary layer is generated inside the tunnel. However, at low pressures (corresponding to the range of Martian surface pressures), it is necessary to “trip” the boundary layer in the entrance area to ensure that it is turbulent. This is accomplished by using spires at the entrance to the tunnel and strips of chain oriented normal to the flow at 60 cm intervals and at approximately 3.5 meters downstream from the entrance section. The resulting wind-tunnel boundary-layer corresponds to a neutrally stratified atmosphere in which the Monin-Obukhov stability length is infinite, hence the ratio of the local surface roughness height to the stability length is zero. In addition, the wind profile is also measured using a traversing pitot-tube. Typical wind profiles are shown in Figure 2.

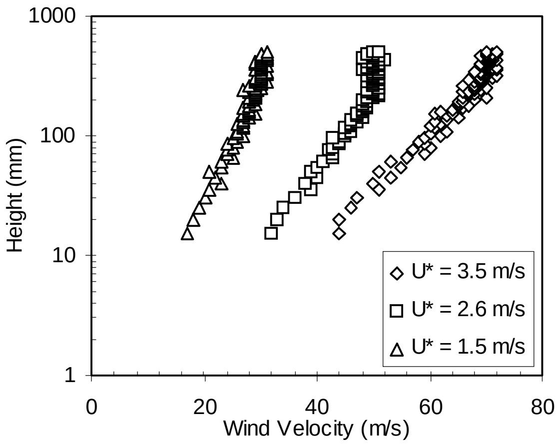

Figure 2. Wind velocity profiles at 10 mb pressure.

Flux rates are determined by obtaining the initial weight of each disk after covering the test bed with CRC dust and by getting the final weights after an experimental run. Using a scale with a resolution of 1×10^{-5}g, the difference in weight is calculated and noted as the amount of dust particles removed. Experiment run times range from 60 to 300 seconds.

The experiments were conducted in air at 10 mb pressure and 293K temperature providing the same Martian CO_2 atmospheric density at 6 mb and 240K.

Results: Preliminary results from this experiment show that threshold and flux of the dust particles are highly dependent on particle charge. Threshold friction velocity was found to be highly variable with ranges of 2.58 to 3.48 m/s. When the surface was charged to the same polarity as that of the particles, the threshold friction velocity decreased. Grounding the surface had a similar effect, but when the surface was charge to the opposite polarity, electrostatic attraction increased threshold values (Figure 3).

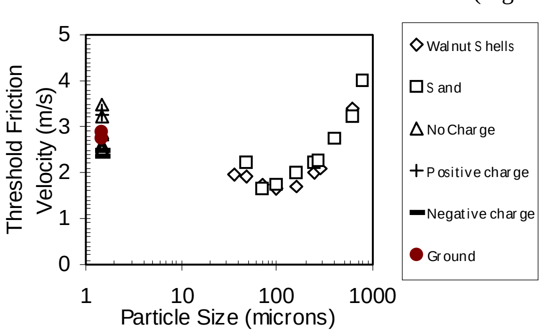

Figure 3. Threshold friction velocity curves for walnut shells, sand and dust at 10 mb pressure.

Flux of particles were also highly variable and found to be functions of surface charge. It should be noted that the flux measurements are only first order estimates because the amount of dust is limited and steady-state erosion rates are not possible to achieve. The current results show a weak linear relationship with friction velocity where the flux of dust particles increased when the surface was charged negatively and decreased when grounded or charged negatively (Figure 4).

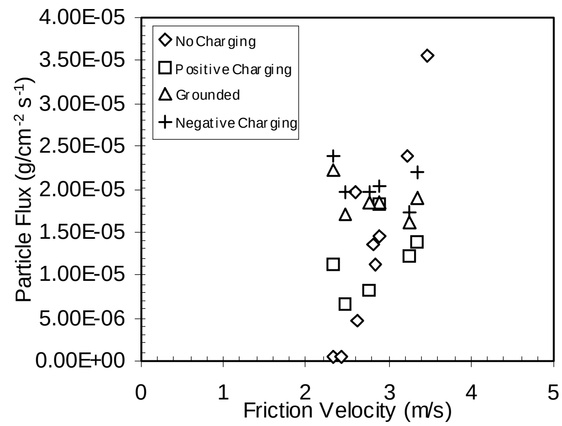

Figure 4. Dust flux at 10 mb pressure.

Summary: Threshold and flux of 1-2 µm dust do not conform to the same physics as that of 10-1000 µm particles. The results here are highly variable and show that electrostatic forces play an important role in determining threshold and flux. These results, however, are consistent with Viking observations. Ultimately, future work will deal with surface roughness effects and the mechanics of particle charging. Improvements in flux measurement techniques and a quantification of electrostatic effects should result in a refinement in threshold and flux curves for particles of these sizes.

References: [1] White, B. R., B. M. Lacchia, R. Greeley, and R. N. Leach. 1997. The aeolian behavior of dust in a simulated Martian environment. *J. Geophys. Res.* Accepted. [2] S. J. Desch and G. R. Wilson. 1997 Electrostatic charging of saltating particles. *LPSC XXVIII abstract.* Submitted. [3] Greeley, R. and R. N. Leach. 1978 A Preliminary Assessment of the Effects of Electrostatics on Aeolian Processes Reports Planetary Geology Program 1977-1978 NASA TM 79729, p. 236.